

Lecture 1
5 April 2003

BLACK HOLE JET

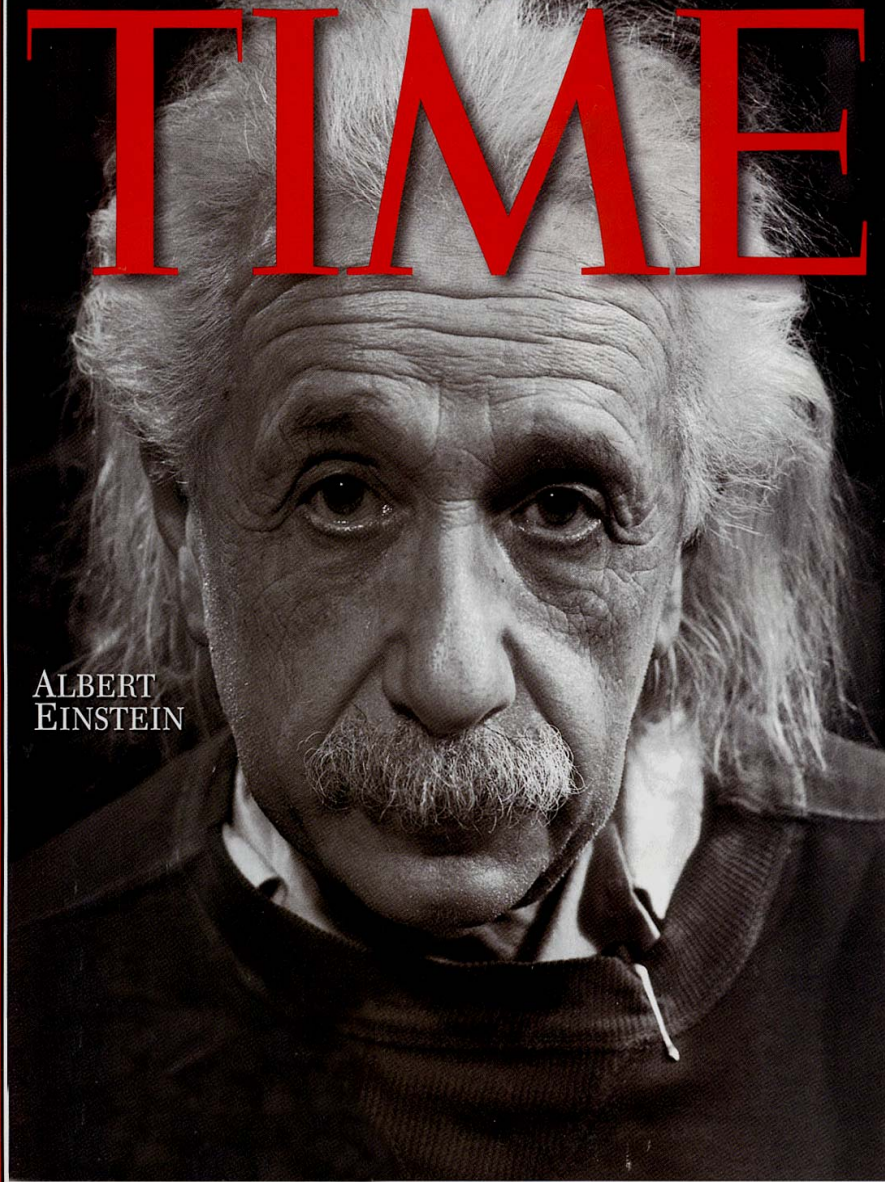
DECEMBER 31, 1999 \$4.95

www.time.com

PERSON OF THE CENTURY

TIME

ALBERT
EINSTEIN



THE AUTHORIZED COMPANION TO
THE PUBLIC TELEVISION SERIES



Stephen Hawking's Universe

THE COSMOS EXPLAINED

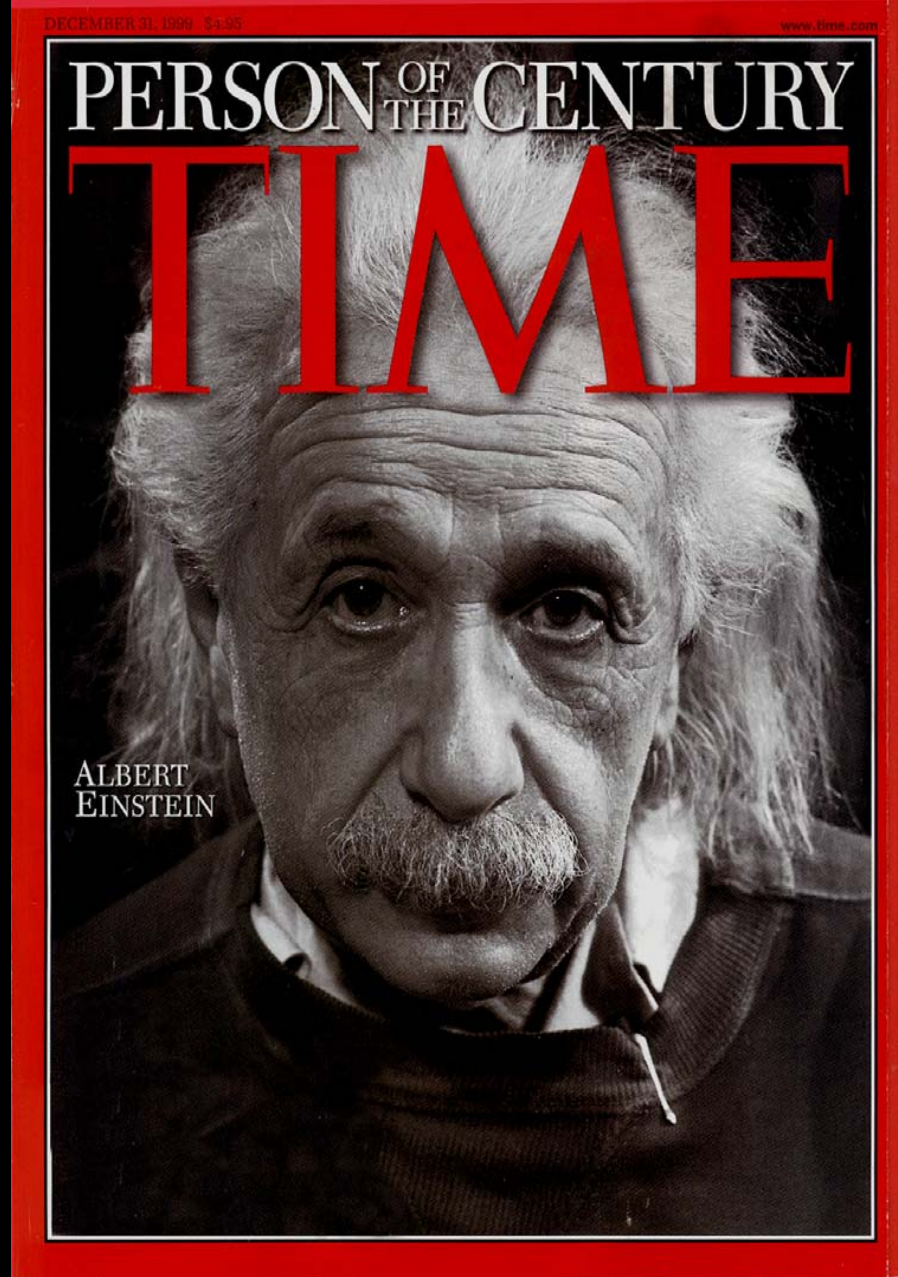
DAVID FILKIN

FOREWORD BY STEPHEN HAWKING

It's
your
universe
too!



Einstein, ca. 1912



Einstein, ca. 1952



"When the Special Theory of Relativity began to germinate in me, I was visited by all sorts of nervous conflicts... I used to go away for weeks in a state of confusion."

"A storm broke loose in my mind."

Einstein, ca. 1905

***Every cubic inch of space is a
MIRACLE!***

- Walt Whitman

- background radiation
- virtual particles
- Higgs potential
- dark matter
- dark energy

A woman with blonde hair, wearing a pink shirt, is looking at a large, crumpled piece of paper. The paper has a grid of small, dark, rectangular images, possibly photographs or documents, arranged in rows and columns. The text "TUVA OR BUST!" is overlaid in large, bold, blue capital letters across the middle of the image.

TUVA OR BUST!

NEW YORK TIMES BESTSELLER

**"SURELY
YOU'RE JOKING,
MR. FEYNMAN!"**

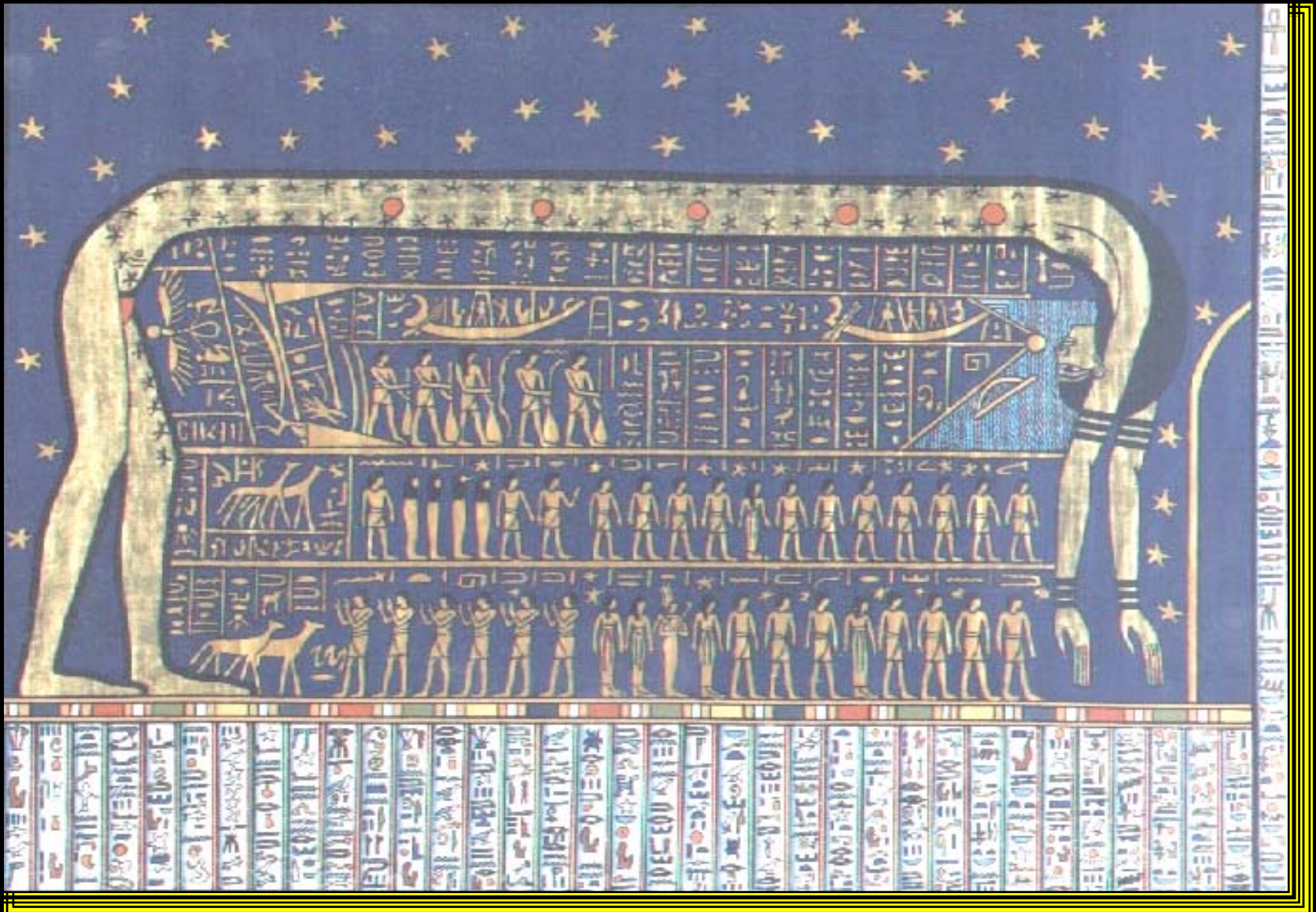
...

**Adventures
of a Curious
Character**

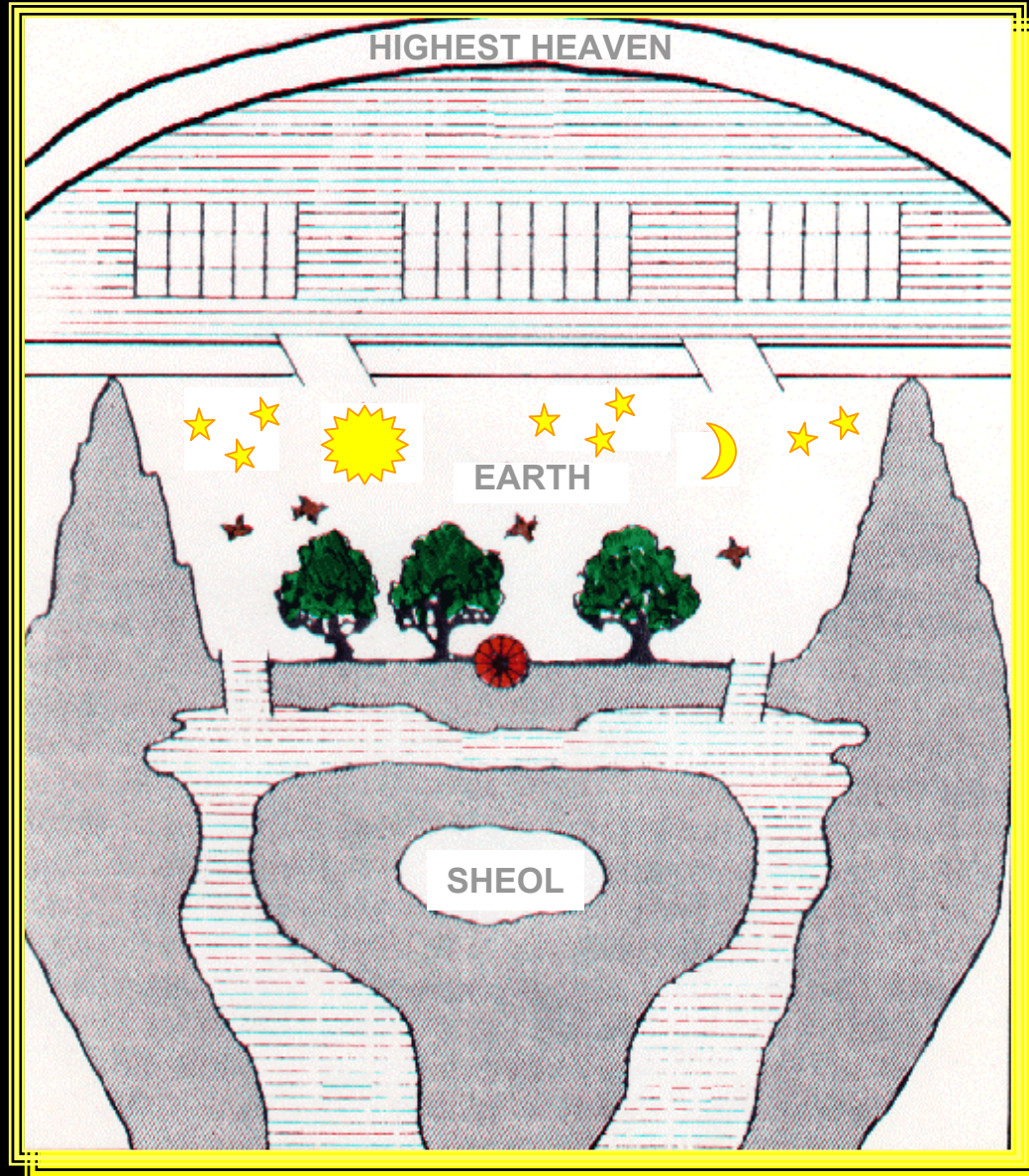
"Quintessential Feynman—funny, brilliant, bowdy."—The New Yorker

RICHARD P. FEYNMAN

A view of the universe, circa 2000 B.C.

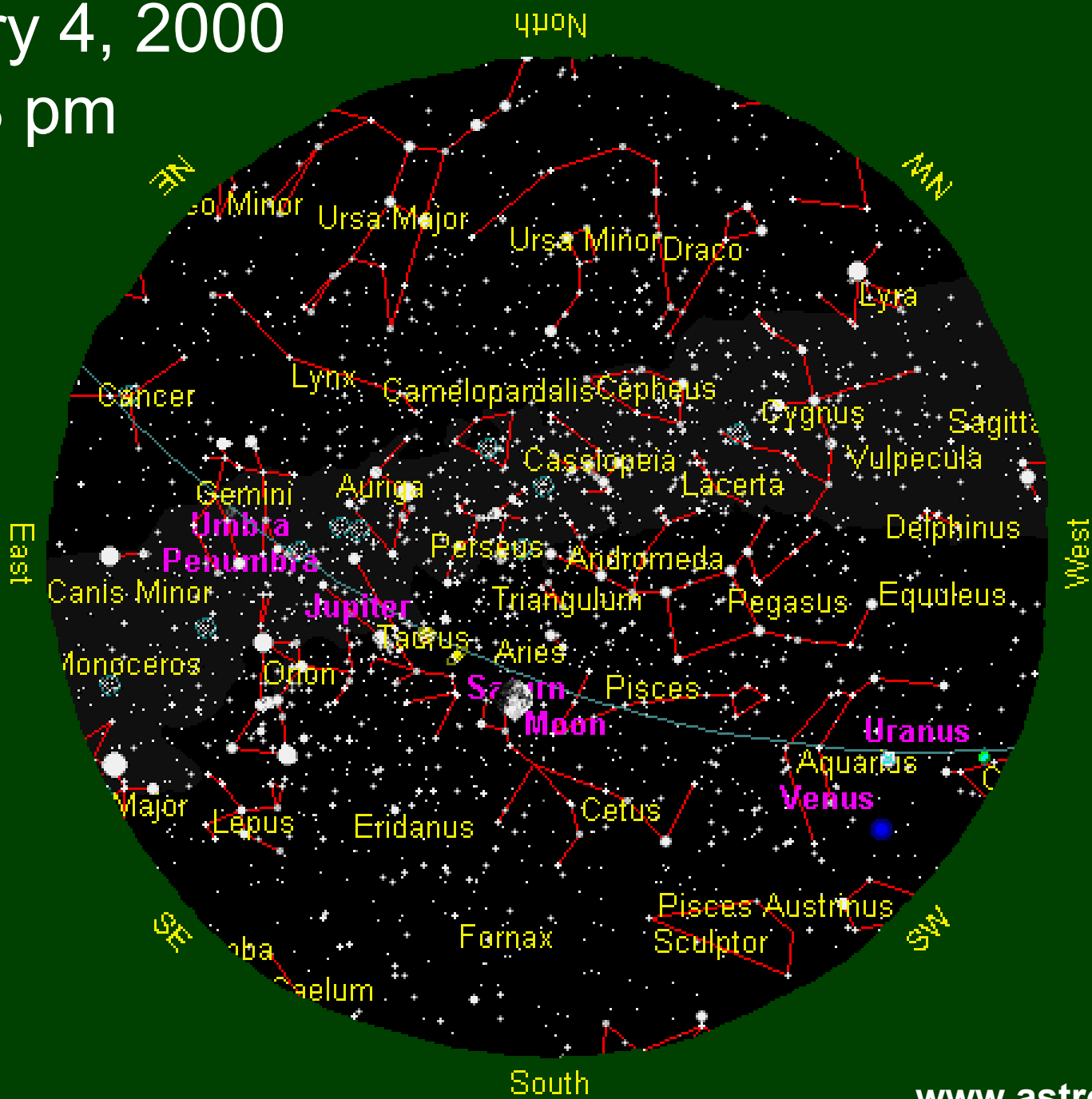


A view of the universe, circa 1000 A.D.*



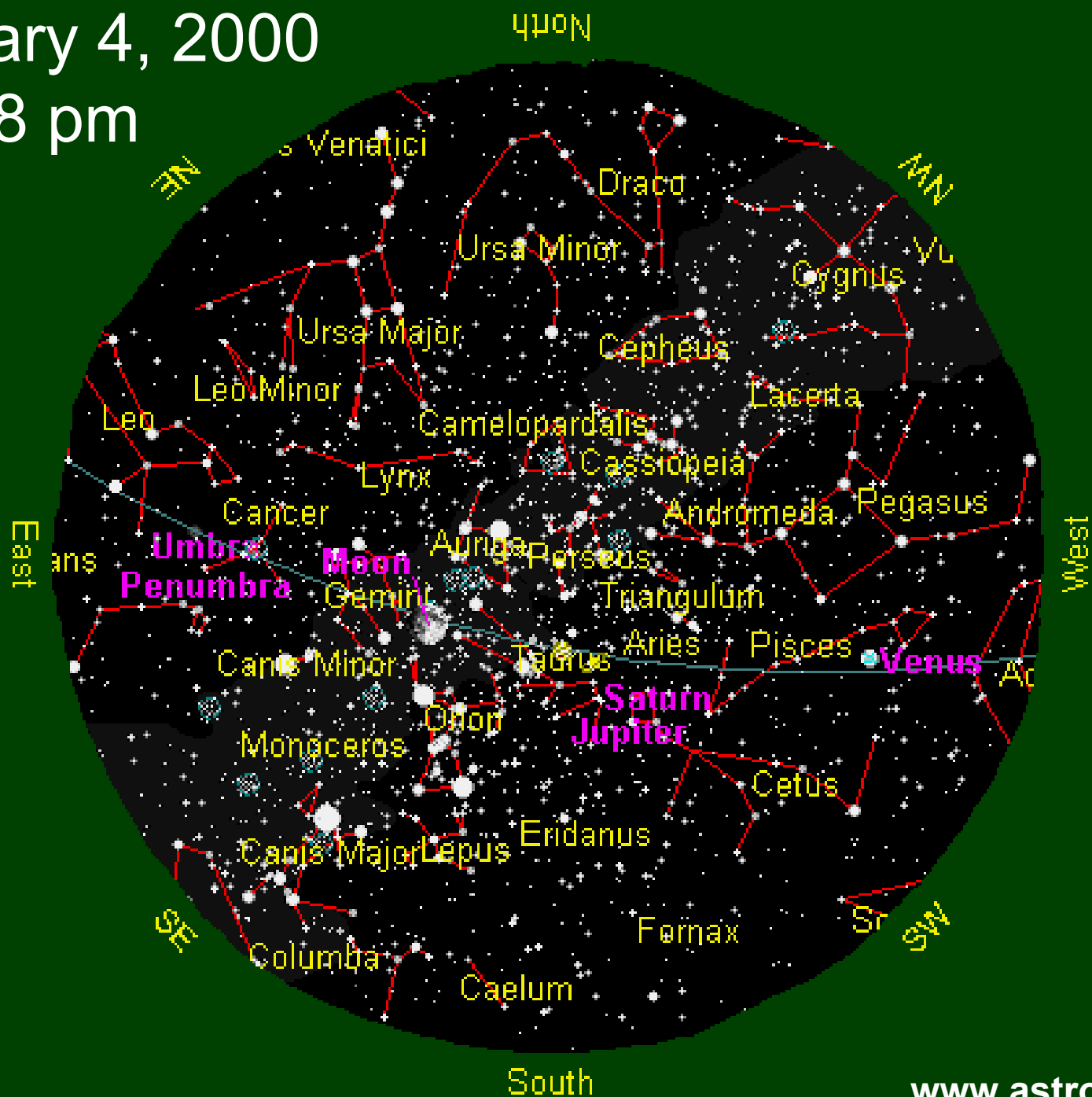
*and circa 2003 A.D. in parts of Kansas

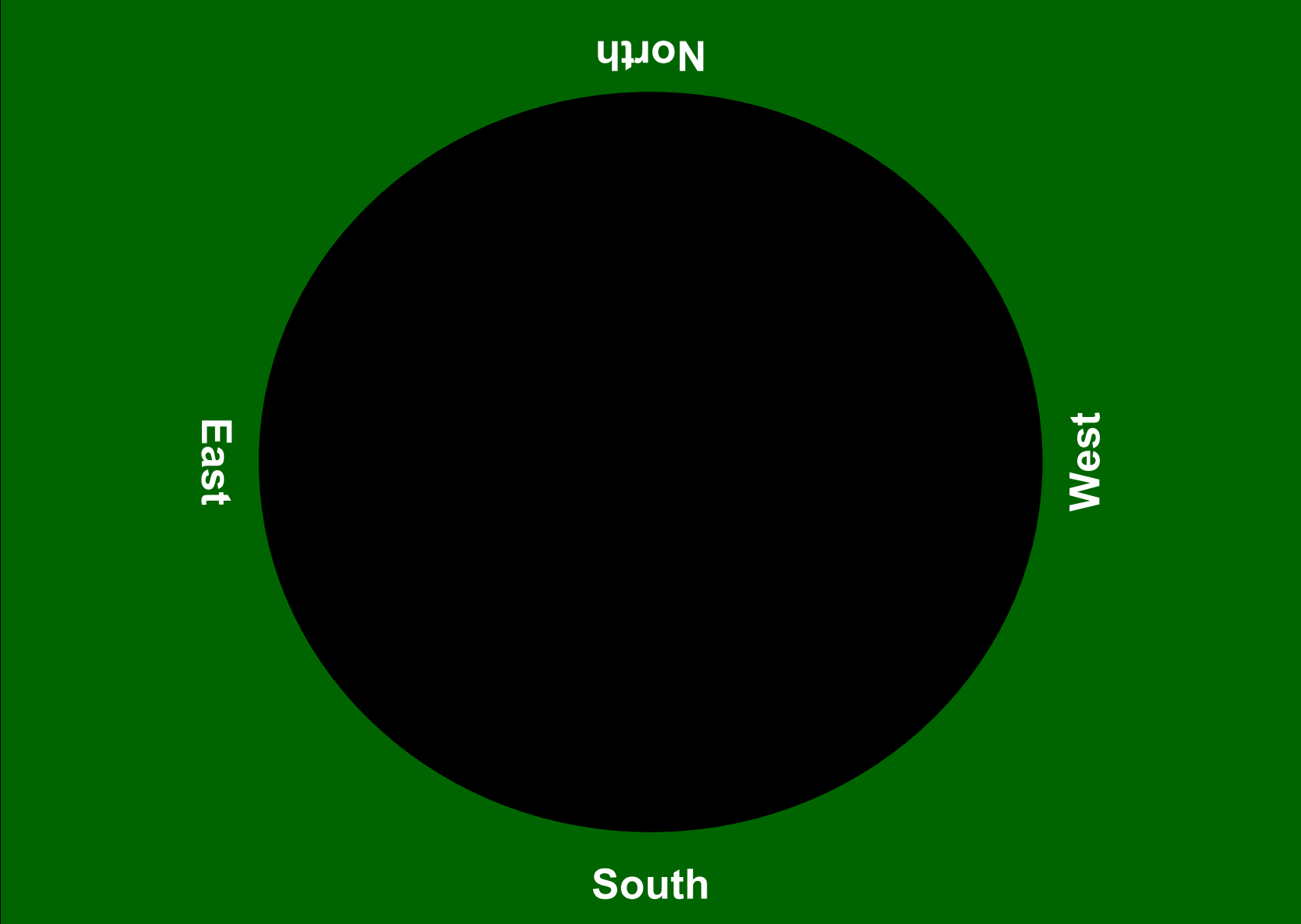
January 4, 2000
8 pm



February 4, 2000

8 pm





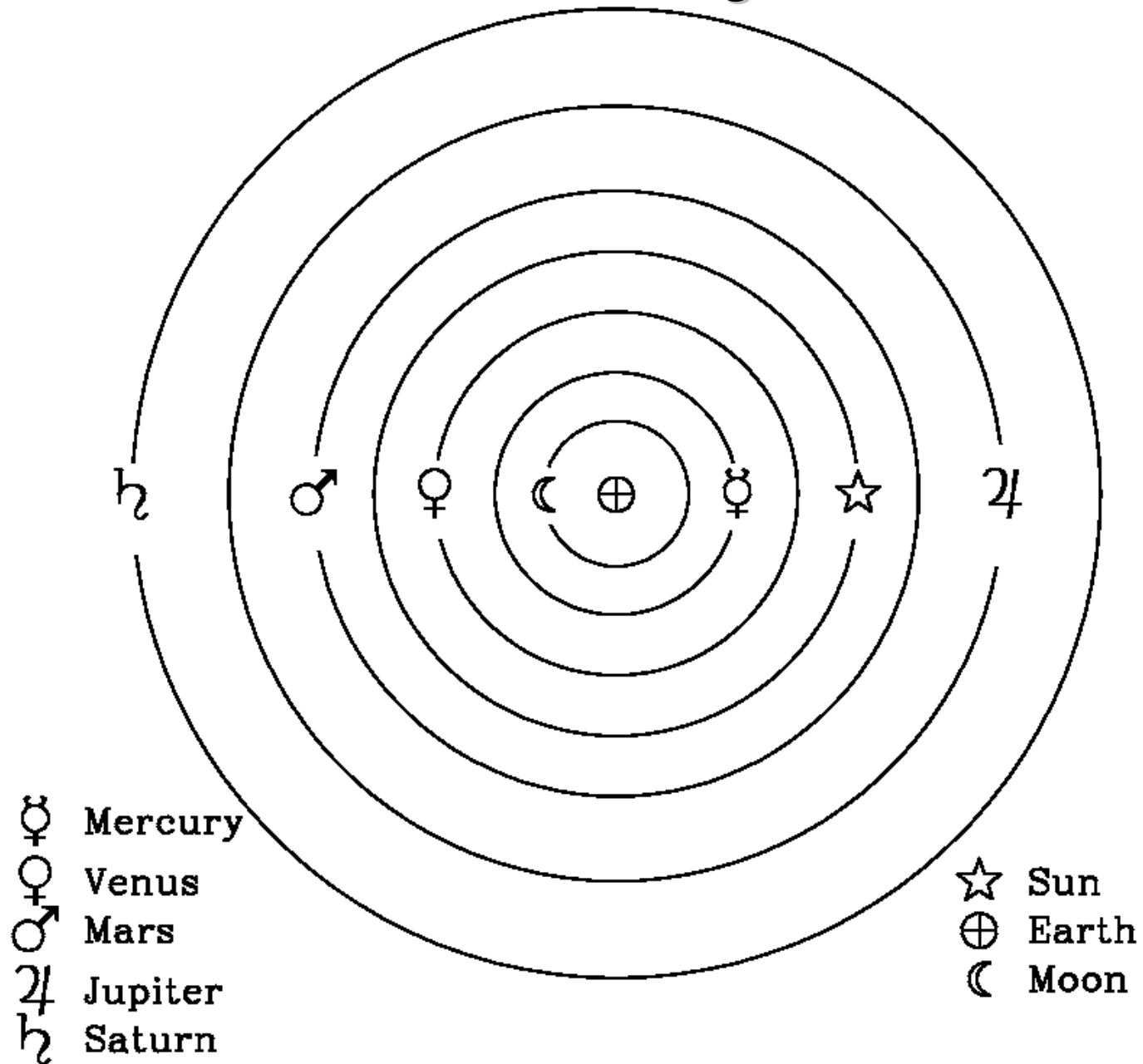
North

South

East

West

The Universe According to Aristotle



N

VIRGO

Feb 1

May 1

15

Jun 1

Mar 1

15

15

15

E

15 Apr 1

λ

15

Jul 1

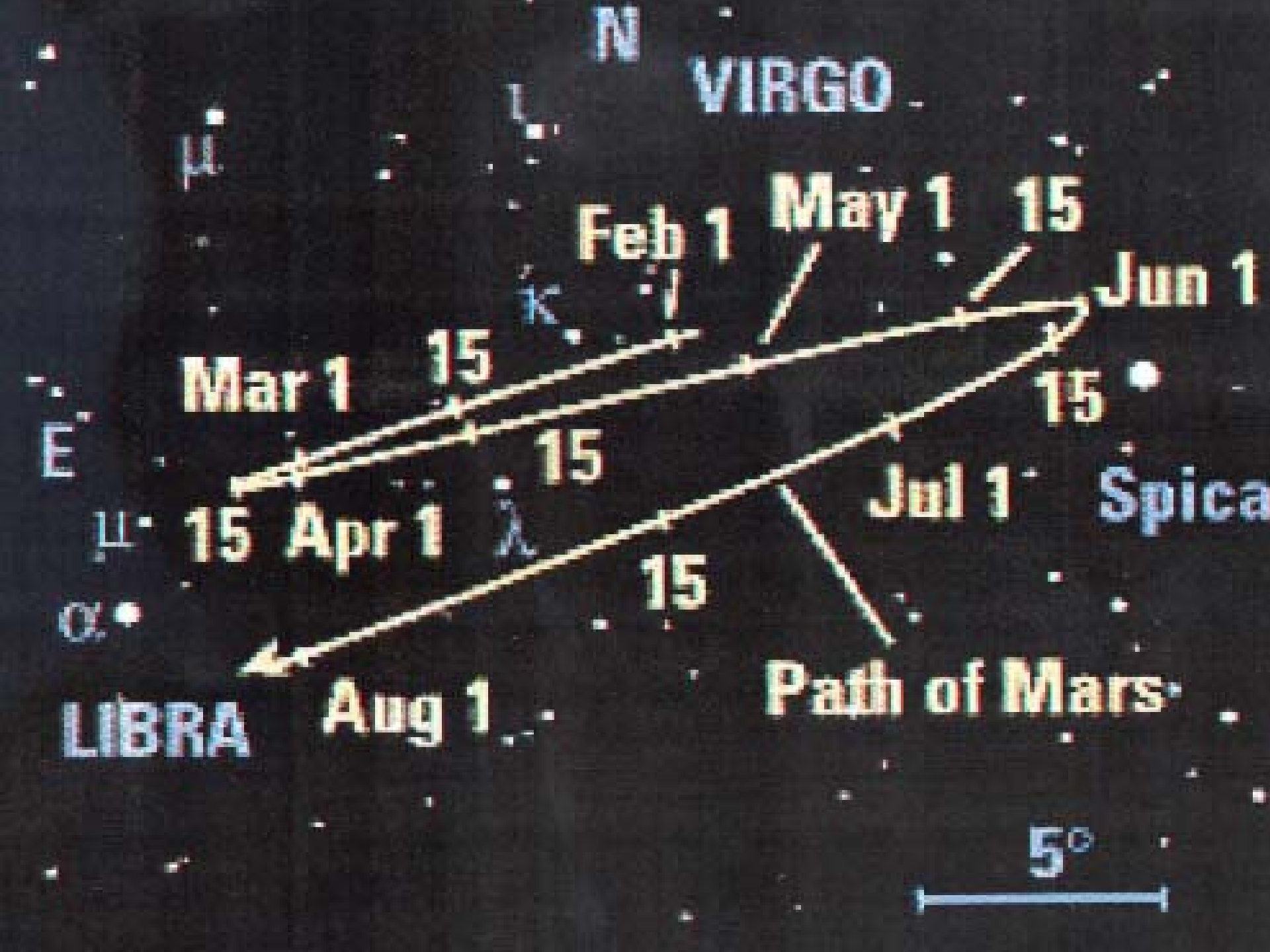
Spica

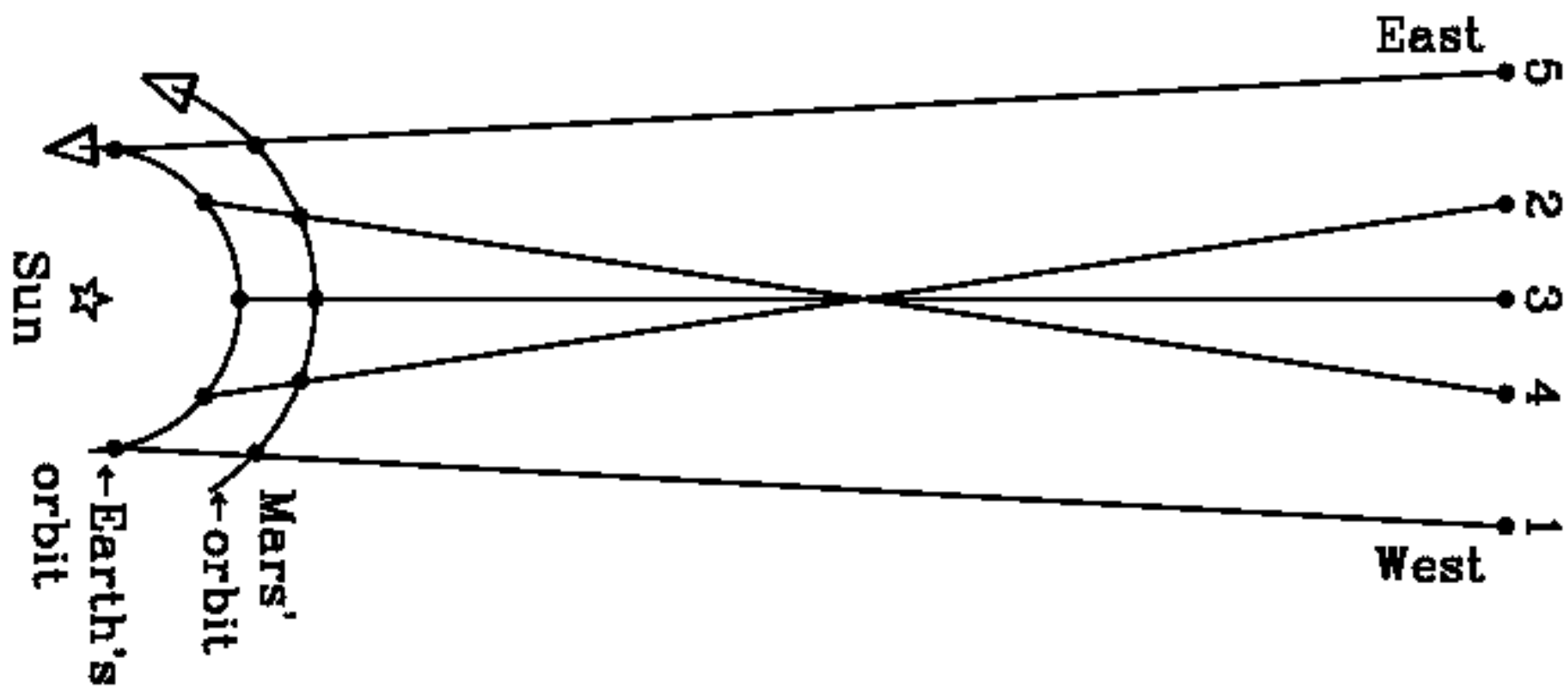
LIBRA

Aug 1

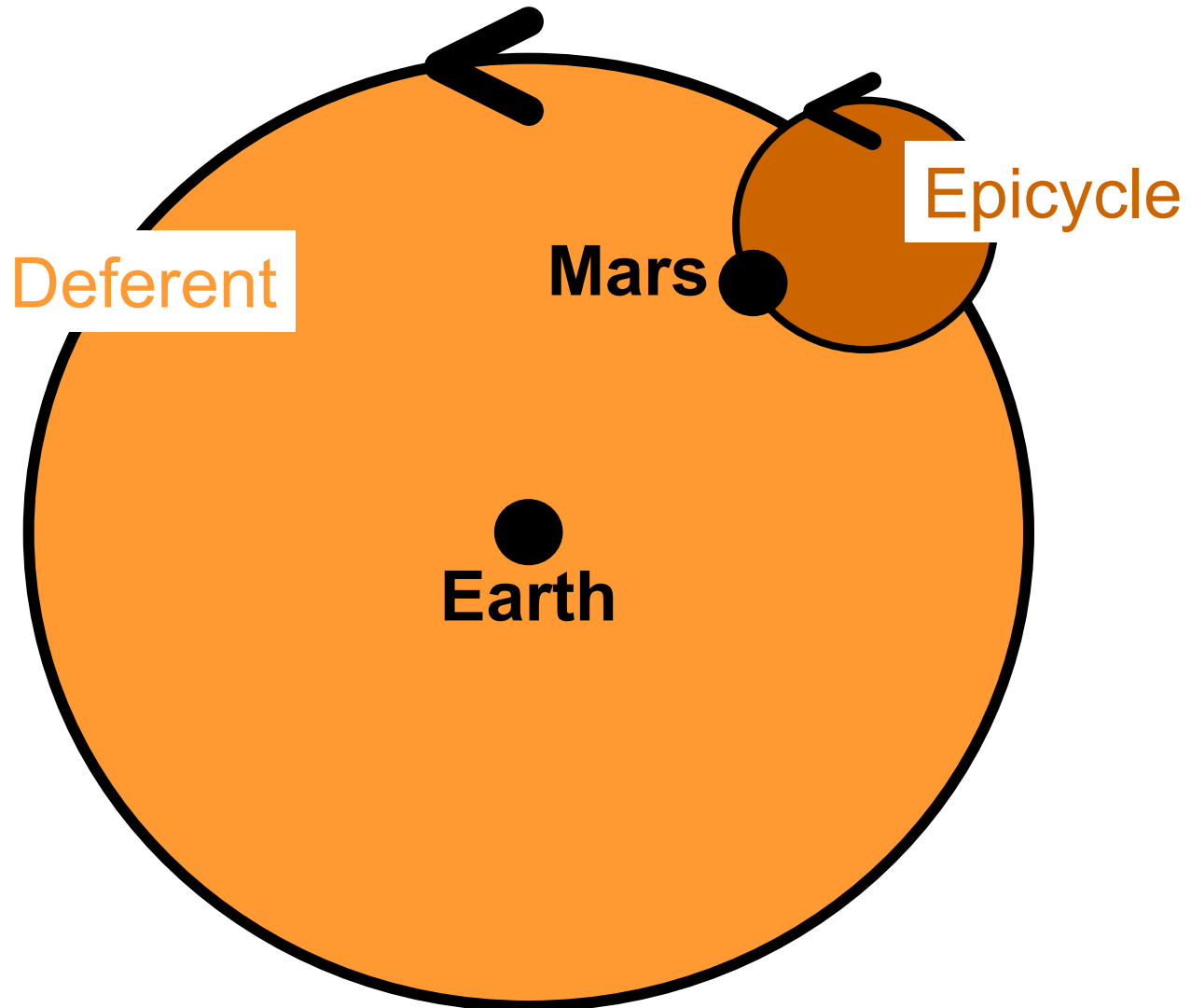
Path of Mars

5°

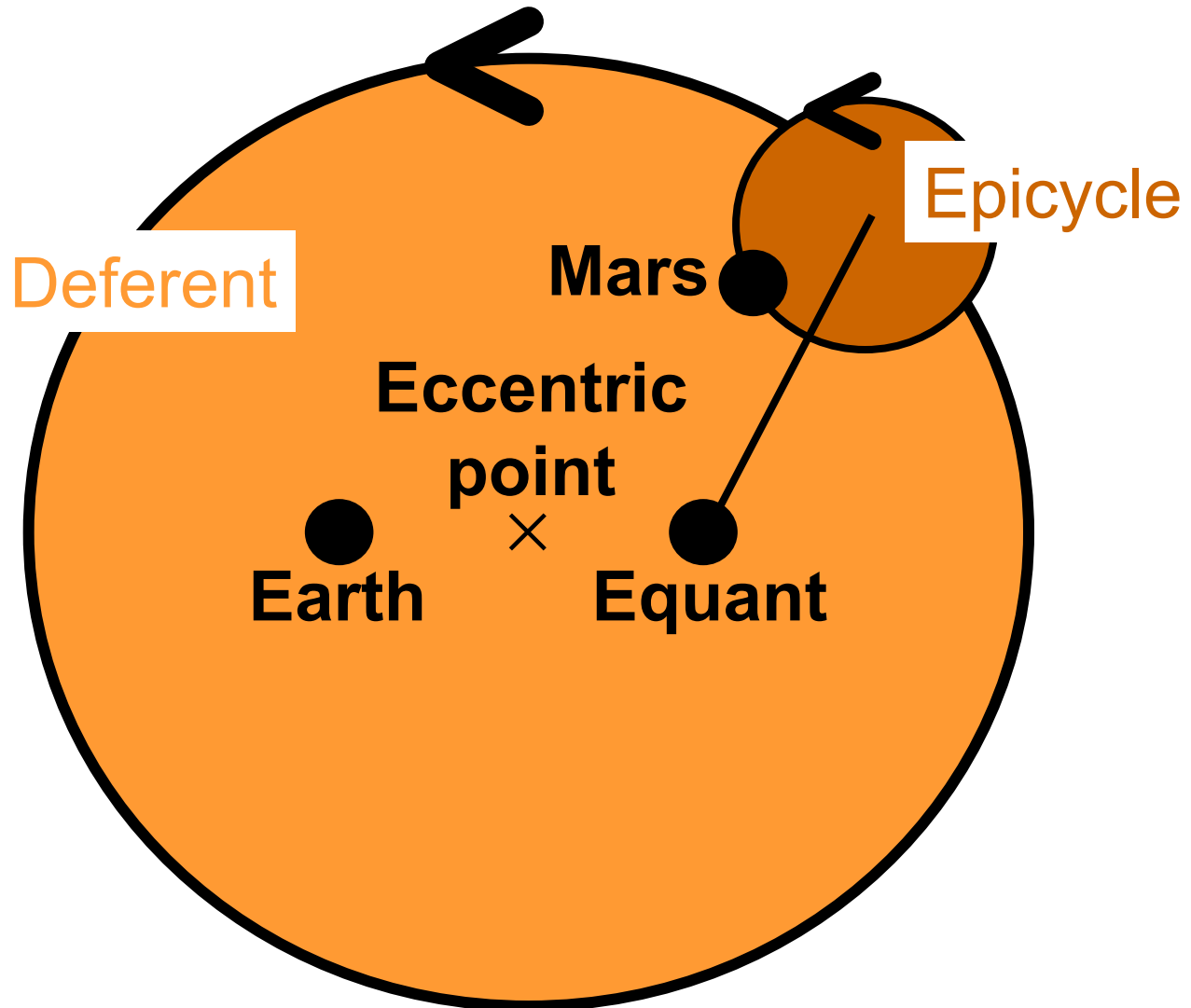




The Ptolemaic Epicycle



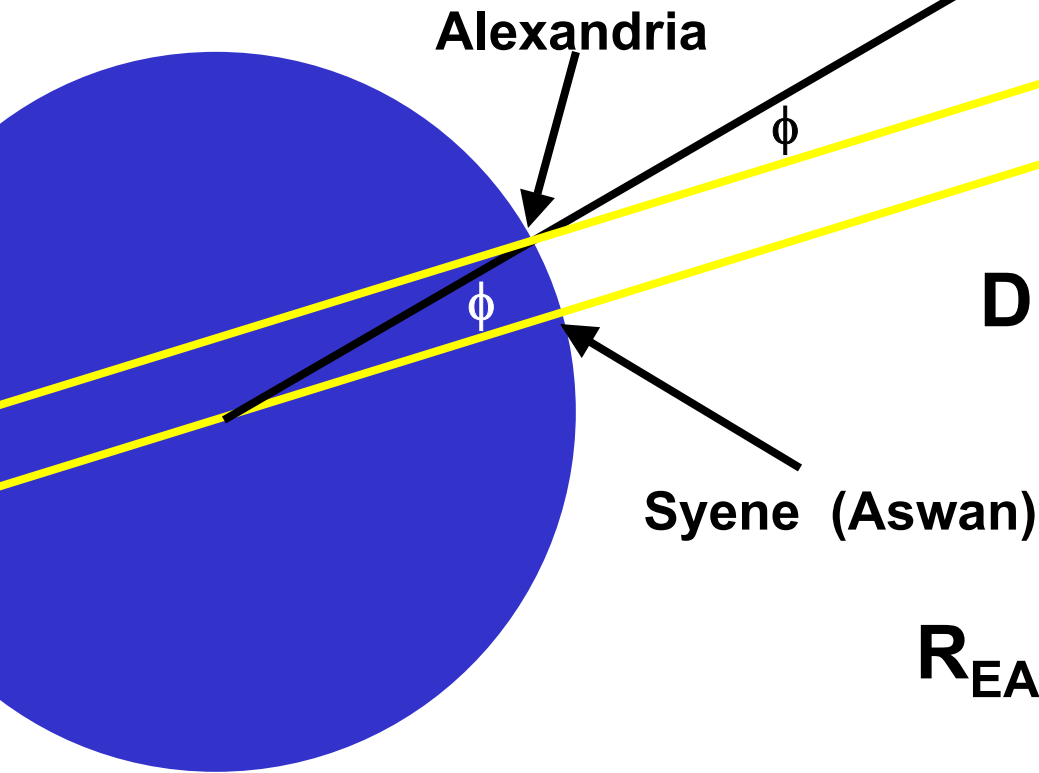
The Ptolemaic Epicycle



Size of Earth (Erathosthenes ~ 250 BC)

D = distance between Syene & Alexandria = 5000 stadia

$$\phi = 7.2^\circ$$

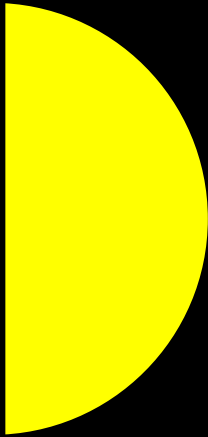


$$D = 2 \pi R_{\text{EARTH}} \frac{7.2^\circ}{360^\circ}$$

$$\begin{aligned} R_{\text{EARTH}} &= 40,000 \text{ stadia} \\ &= 6,350 \text{ km} \end{aligned}$$

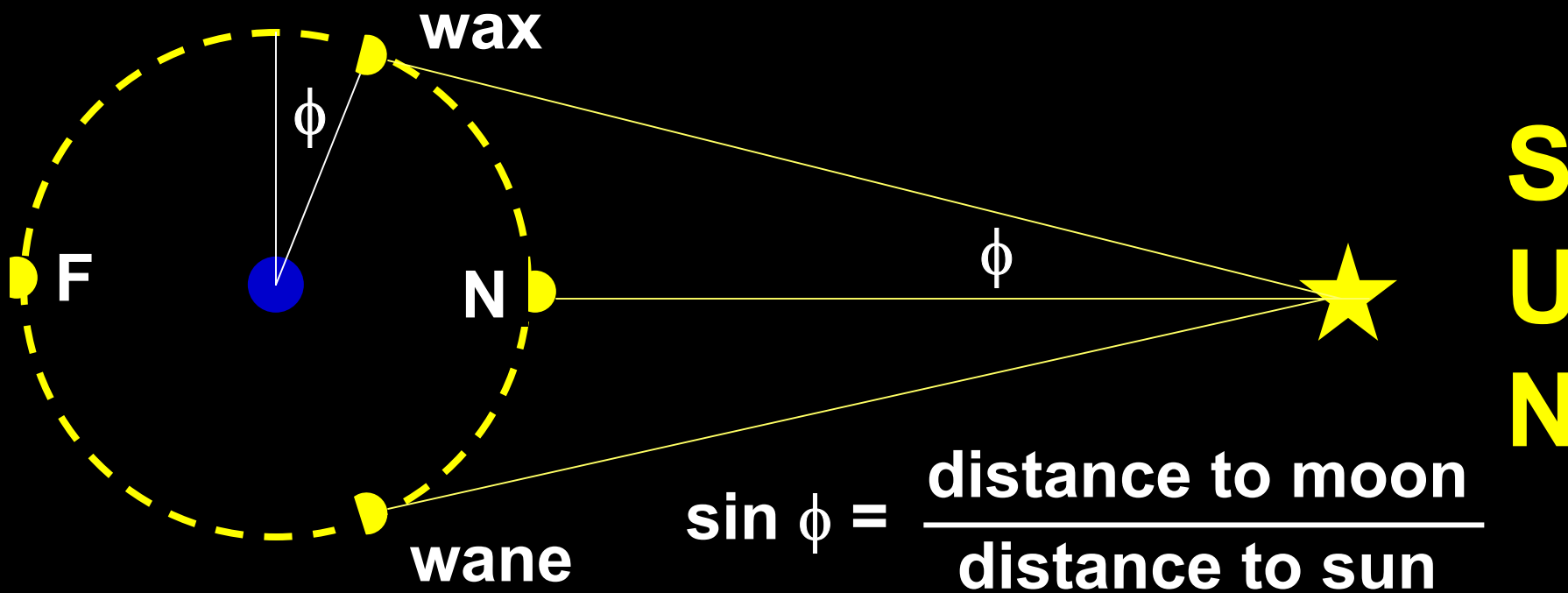
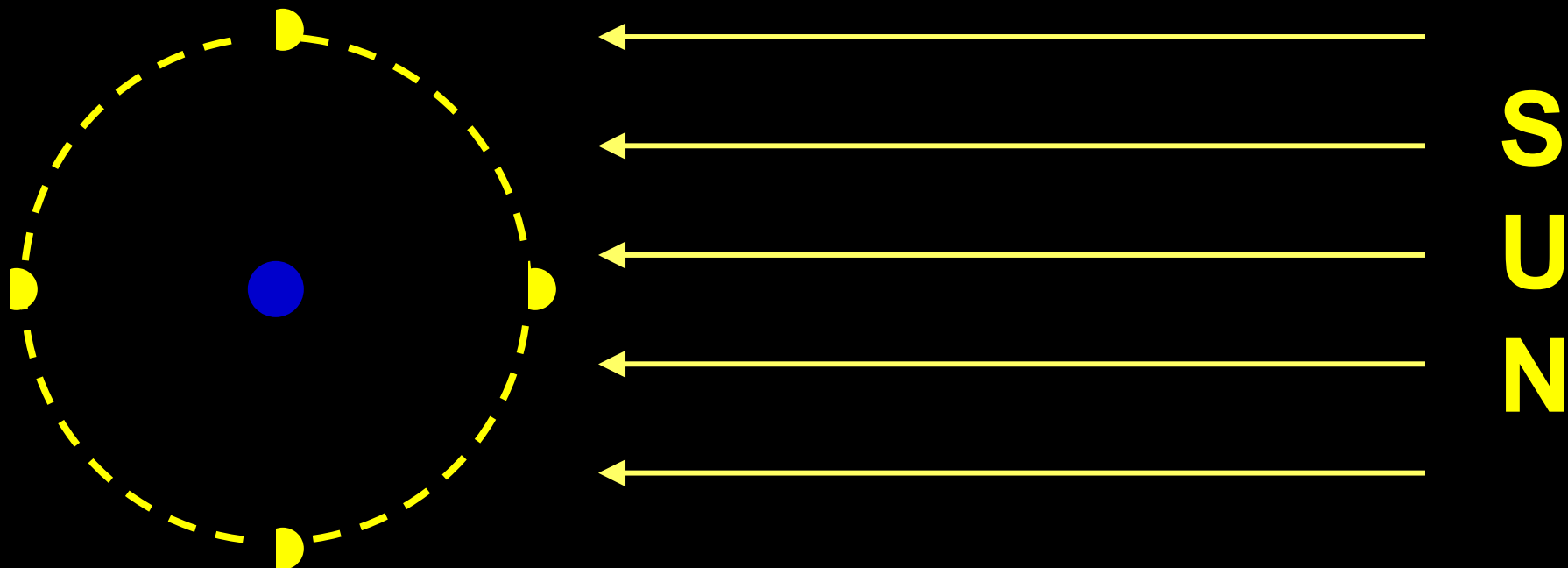
$$\frac{\text{distance to the sun}}{\text{distance to the moon}}$$

(Aristarchus ~ 270 BC)



S
U
N

sun always illuminates half the moon



Aristarchus said time between new moon and waxing moon was 12 hours shorter than the time between the full moon and the waning moon.

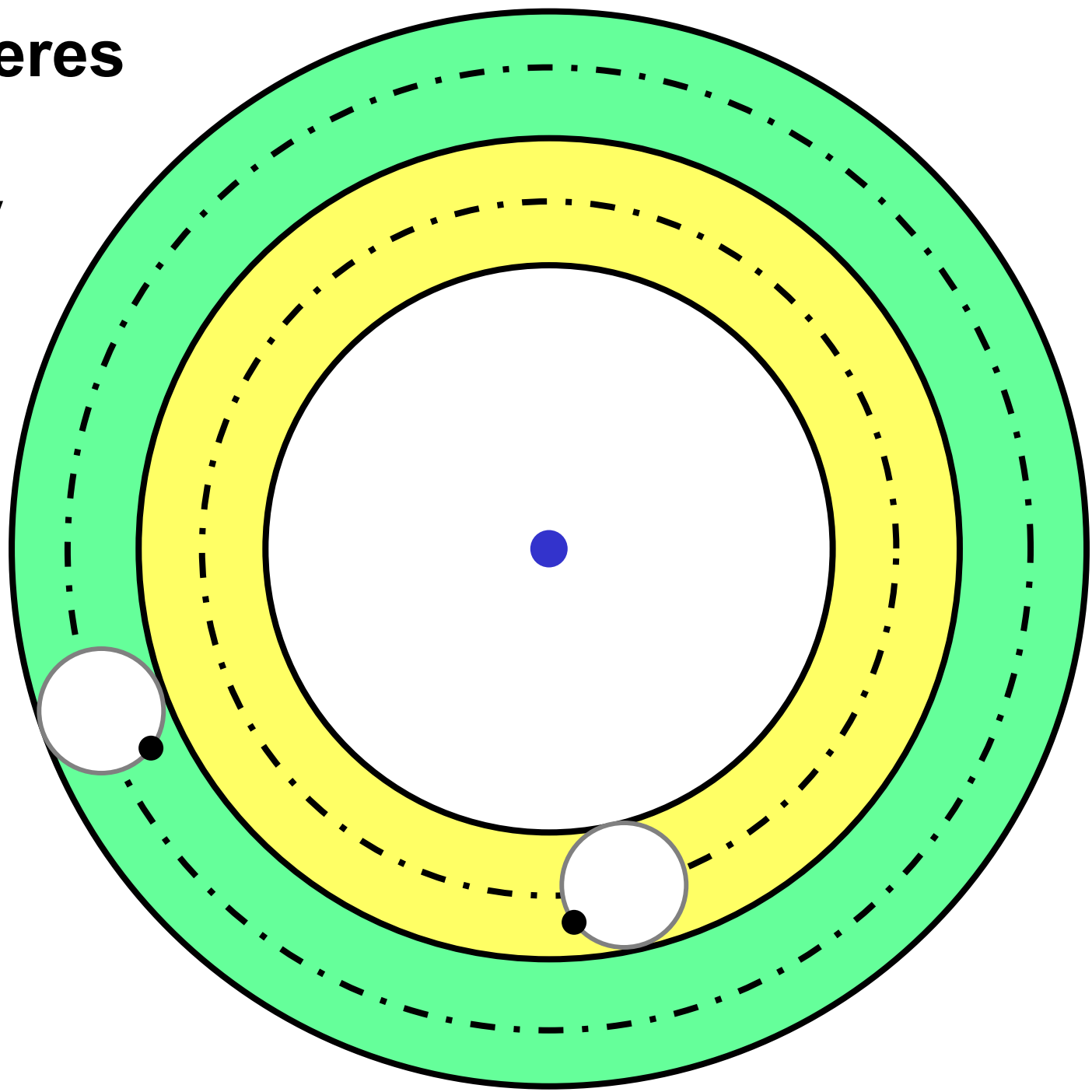
$$\frac{\text{distance to moon}}{\text{distance to sun}} = 19$$

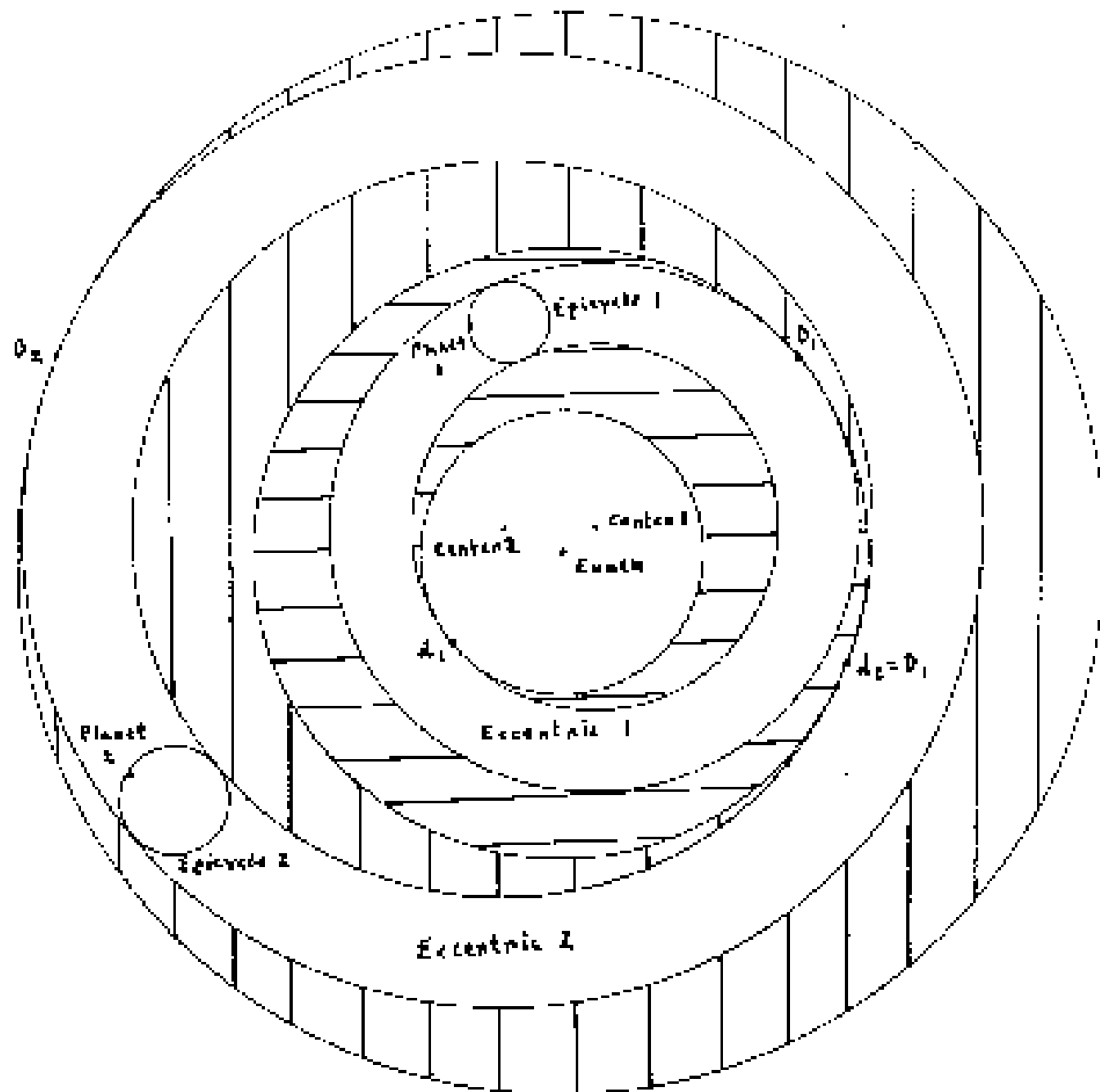
**390 is correct
but geometry is perfect**

Object	Distance from Earth (in miles)		Radius (in miles)		Angular Size (in degrees)	
	Ptolemy	True	Ptolemy	True	Ptolemy	True
Earth	————	————	3,750	3,960	————	————
Moon	225,000	239,000	940	1,080	1/2	1/2
Sun	4,700,000	92,900,000	21,000	432,000	1/2	1/2

Nested Spheres of Ptolemy

- Earth
- Planet
- - - Deferent
- Epicycle





Planet	Distance from Earth (in millions of miles)		Angular Diameter (in minutes)		Actual Diameter (in miles)	
	Ptolemy	True	Ptolemy	True	Ptolemy	True
Earth	————	————	————	————	7,500	7,900
Mercury	0 .6	147	2	0.01	300	3,000
Venus	4	66	3	0.5	1,900	7,500
Mars	33	126	1.5	0.15	8,600	4,200
Jupiter	53	1,000	2.5	0.4	32,500	89,000
Saturn	74	2,000	1.7	0.2	32,000	75,000



Raphael, School of Athens, in the Stanza della Segnatura



A



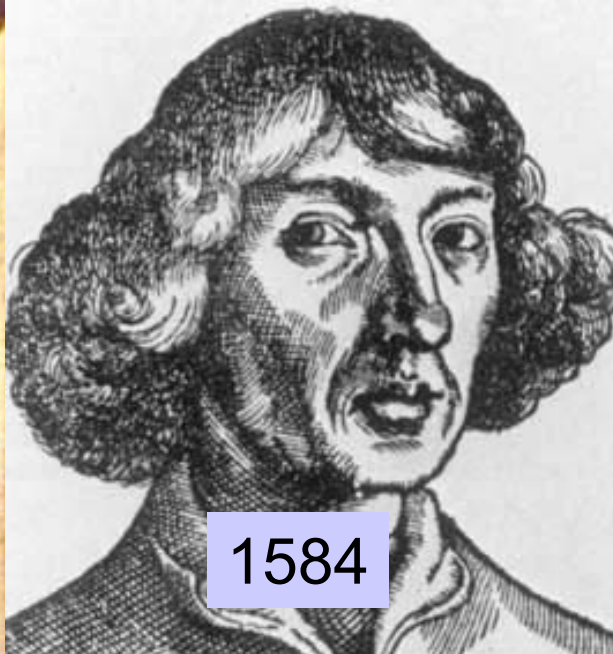
B



C



Nicholas Copernicus
1473 - 1543



Nicolaus Copernicus of Torun
Six Books on the Revolutions of the Heavenly Spheres

Diligent reader, in this work, which has just been created and published, you have the motions of the fixed stars and planets, as these motions have been reconstituted on the basis of ancient as well as recent observations, and have moreover been embellished by new and marvelous hypotheses. You also have most convenient tables, from which you will be able to compute those motions with the utmost ease for any time whatever. Therefore buy, read, and enjoy (*eme, lege, fruere*).

Let no one untrained in geometry enter here.

Nuremberg
Johannes Petreius
1543